OROVILLE FERC RELICENSING
(PROJECT NO. 2100)

INTERIM REPORT
SP-F3.2 TASK 2
SP-F21 TASK 1

APPENDIX A
MATRIX OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR FEATHER RIVER FISH SPECIES

LITERATURE REVIEW OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR FEATHER RIVER FISH SPECIES

HITCH

JANUARY 2003

Element	Element Descriptor	General	Feather River Specific
General			
common name (s)	English name (usually used by fishers and laypeople).	Hitch	
scientific name (s)	Latin name (referenced in scientific publications).	*Lavinia exilicauda* Clear Lake hitch (*L. e. chi*) Sacramento hitch (*L. e. exilicauda*) Monterey hitch (*L. e. harengus*) (Moyle et al. 2000)	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Minnows - *Cyprinidae*	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	Populations of hitch are found throughout the Central Valley, from the Tulare Lake basin in the southern San Joaquin River drainage to Shasta Reservoir in the northern Sacramento River drainage. In San Francisco Bay, hitch are found in Coyote Creek, Alameda Creek, and other creeks in Santa Clara, Contra Costa, and Alameda counties. Near Monterey Bay, hitch occur in Pajaro and Salinas reservoirs and in large tributaries. A small population is also present in the Russian River. Hitch are found throughout Clear Lake and Lake County (Moyle 2002). Hitch once exhibited a wide distribution in the large streams within the Sierra Nevada foothills, but now occur only as scattered populations (Moyle et al. 1974).	

Element	Element Descriptor	General	Feather River Specific
native or introduced	If introduced, indicate timing, location, and methods.	Hitch are native to the Sacramento-San Joaquin river region, Clear Lake, the Russian River, and the Pajaro - Salinas drainages (Moyle 2002). Hitch were introduced into Beardsley Reservoir (Tuolumne County) and Bass Lake (Fresno County) (Moyle 2002). Hitch move via the California Aqueduct to San Luis Reservoir (Merced County), and Pyramid and Silverwood reservoirs (L.A. County) (Moyle 2002).	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.	Hitch are not listed.	
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	Hitch are freshwater fish and the status of all forms is “watch list,” except for the Clear Lake hitch (*Lavinia exilicauda chi*), whose status is “special concern” (Moyle 2002).	
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	Hitch are commercially harvested on occasion from Clear Lake (Moyle 2002). Hitch are sometimes used as bait, and have also been sold in fish markets for human consumption (Wang 1986).	

Element	Element Descriptor	General	Feather River Specific
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.	Hitch are warmwater fish.	
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.	In lakes, adult hitch are usually pelagic. Clear Lake juvenile hitch are found in near-shore shallow-water habitats and move into deeper offshore areas after approximately 80 days, when they are between 1.6 and 2 inches (40 and 50 mm) in length (Moyle 2002).	
bottom or water column distribution	Environment: bottom (benthic) or along water column.		
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Hitch are widespread in warm, low-elevation lakes, sloughs, and slow-moving stretches of river, and in clear, low-gradient streams (Moyle 2002).	
Adults			
life span	Approximate maximum age obtained.	Hitch typically live 4 to 6 years, though larger hitch may be older than this (Moyle 2002). Female hitch mature during their second or third year, while males mature during their first, second, or third year (Moyle 2002).	
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	Growth rates of hitch are directly related to summer water temperatures (Moyle 2002). Clear Lake hitch reach 1.6 to 2 inches (40 to 50 mm) in length in the first 3 months, 4.3 to 6.7 inches (110 to 170 mm) in length at the end of the first year, and 5.9 to 11.8 inches (150 to 300 mm) in length at the end of the second year. Hitch grow 0.8 to 2 inches/year (20 to 50 mm/year), with a maximum length of 13.8 inches (350 mm) (Moyle 2002). Beardsley Reservoir hitch reach 1.6 to 2 inches (40 to 50 mm) in length at the end of the first year, 3.5 to 4.3 inches (9 to 11 cm) in length at the end of the second year, with subsequent yearly increments of 0.8 to 1.6 inches/year (20 to 40 mm/year) (Moyle 2002).	

Element	Element Descriptor	General	Feather River Specific
		In Putah Creek, the average length for hitch is 2.6 inches (65 mm) at the end of the first year and 7.9 to 9.8 inches (200 to 250 mm) in 3 to 4 years (Moyle 2002).	
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.	In the Pajaro River, both sexes of hitch mature during their second summer at 1.9 to 2.1 inches (49 to 54 mm) in length, and most fish over 2.8 inches (70 mm) in length are mature (Moyle 2002).	
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.	Hitch have deep, laterally compressed bodies, small heads with upward-pointing mouths, moderately large scales, and decurved lateral lines. The hitch body tapers to a narrow caudal peduncle, which supports a large, forked tail (Moyle 2002).	
coloration	Indicate color, and color changes, if any, during reproduction phase.	Small hitch are silvery with a black spot at the base of the tail. Older hitch lose the spot and become darker, with the largest hitch approaching brownish-yellow on the back (Moyle 2002). Male hitch exhibit a rusty color on the paired fins during spawning (Wang 1986).	
other physical adult descriptors	Unique physical features for easy identification.	The long anal fin separates the hitch species from most other California minnows (Moyle 2002).	
adult food base	Indicate primary diet components.	Adult hitch primarily feed on zooplankton, filamentous algae, aquatic insects, and terrestrial insects (Moyle 2002).	
adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	Hitch are omnivorous, open-water feeders, primarily feeding during the day (Moyle 2002).	
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.	N/A	

Element	Element Descriptor	General	Feather River Specific
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.	N/A	
Adult upstream migration (immigration)			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.	Hitch spawning migrations usually take place from mid-March through May, and occasionally into June (Moyle et al. 1995).	
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.	N/A	
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	N/A	
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	N/A	
Adult holding (freshwater residence)			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Hitch have the highest water temperature tolerance among native fishes of the Central Valley (Moyle 2002). Hitch can withstand water temperatures ranging from as high as 85°F to 100.4°F (30°C to 38°C) (Moyle 2002).	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	Hitch prefer water temperatures ranging from 80.6°F to 84.2°F (27°C to 29°C) (Moyle 2002).	
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	Within eight sampled sites in the San Joaquin River drainage, hitch were found at a maximum depth of 3.3 feet (100 cm) (Brown et al. 1993).	

Element	Element Descriptor	General	Feather River Specific
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.		
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Hitch prefer deep pools associated with heavy cover and overhanging trees (Moyle 2002). Typical hitch habitats are streams consisting of a sandy-bottomed substrate (Brown et al. 1993).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.		
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.		
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	The mean elevation of sites where hitch were found was 1,371 feet (418 m) (Brown et al. 1993). Adult hitch can be found in low gradient streams at moderately low elevations, containing a mixture of native and introduced species (Brown et al. 1993).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.	In Clear Lake, the hitch run started in mid-February and persisted until the streams dried up in June (Moyle 2002).	
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.	At Clear Lake hitch spawning migrations usually take place from mid-March to May (Moyle 2002).	
Spawning			
fecundity	Average or range in the number of eggs females lay in a spawning season.	Female hitch within Beardsley Reservoir contained 3,000 to 26,000 eggs, with an average of 9,000 eggs. Female hitch within Clear Lake averaged 36,000 eggs, ranging from 9,000 to 63,000 eggs (Moyle 2002).	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.	N/A	
nest size	Size and average dimensions of the nest.	N/A	

Element	Element Descriptor	General	Feather River Specific
spawning process	Indicate whether nest builder, broadcast spawner, or other.	Hitch are broadcast spawners. A ripe female is closely followed by 1 to 5 males, who fertilize the eggs just after they are released (Moyle 2002).	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Hitch eggs can be deposited on hard clay bottoms and among submerged vegetation (Wang 1986).	
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	Hitch appear to require clean, fine to medium gravel for spawning, although the spawning requirements for hitch needs further documentation (Moyle 2002). Adult Clear Lake hitch spawn in gravel-bottomed stream sections that dry up during the summer (Moyle 2002).	
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Hitch were observed spawning in Pajaro Reservoir at water temperatures ranging from 64.4°F to 78.8°F (18°C to 26°C) (Moyle 2002).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Optimal water temperatures for hitch spawning were observed ranging from 57.2°F to 64.4°F (14°C to 18°C) (Moyle 2002). Optimal water temperature ranges for hitch spawning have been observed at 59°F to 71.6°F (15°C to 22°C) (Wang 1986).	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.		
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.		
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.		
water depth preference for spawning	Reported range of most frequently observed water depth utilization.		
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	Most hitch spawning takes place between March and June (Wang 1986).	

Element	Element Descriptor	General	Feather River Specific
peak spawning timing	Time of year most fish start to spawn.	Within the Pajaro River, hitch spawning was observed between May and July (Moyle 2002).	
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Hitch are iteroparous spawners.	
Incubation/early development			
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Fertilized hitch eggs are not adhesive; they sink into the gravel before absorbing water and swelling to about 4 times their initial size (Moyle 2002). Hitch eggs are spherical and measure 0.06 to 0.09 inches (1.6 to 2.4 mm) in diameter (Wang 1986). Hitch eggs are deposited individually and will float in water if undisturbed (Wang 1986).	
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	The preferred water temperature for hitch egg incubation ranges from 59°F to 71.6°F (15°C to 22°C) (Moyle 2002). The preferred water temperature for hitch egg incubation ranges from 60.8°F to 62.6°F (16°C to 17°C) (Wang 1986).	
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	Hatching of hitch eggs takes place in 3 to 7 days at 59°F to 71.6°F (15°C to 22°C) (Moyle 2002). Hitch egg incubation took 7 days at 60.8°F to 62.6°F (16°C to 17°C) within the Sacramento-San Joaquin drainage system (Wang 1986). Hatching of hitch eggs took place in 3 to 5 days in the laboratory at 59°F to 71.6°F (15°C to 22°C) (Wang 1986).	
size of newly hatched larvae	Average size of newly hatched larvae.	Hitch length at hatching was observed to be 0.2 inches (6 mm) (Wang 1986). Hitch length at hatching can range from 0.17 to 0.2 inches (4.2 to	

Element	Element Descriptor	General	Feather River Specific
		5.5 mm) (Wang 1986).	
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.	Hitch larvae take 3 to 4 days until they are free-swimming (Moyle 2002).	
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Small hitch observed downstream from Clear Lake spent two months in the lakes littoral region, usually among emergent tules (Moyle 2002).	
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.		
timing peak for emergence	Time of year most hatchlings emerge.		
size at emergence from gravel	Average size of hatchlings at time of emergence.	At about 1 inch (25 mm), fry of Clear Lake hitch quickly move down into the lake. Small hitch spend the next 2 months in shoals before moving into open water at about 2 inches (50 mm) in length (Moyle 2002). In California, hitch are 0.25 to 0.27 inches (6.5 to 7 mm) in length at completion of the yolk-sac stage (Wang 1986).	
Juvenile rearing			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.		
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	In the laboratory, juvenile hitch acclimated to 86°F (30°C) and can withstand temperatures of nearly 100.4°F (38°C) (critical thermal maximum) for short periods (Moyle 2002).	
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observa-tional, or experimental derivation.	The preferred temperature for rearing hitch ranges from 80.6°F to 84.2°F (27°C to 29°C) (Moyle 2002).	
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.		

Element	Element Descriptor	General	Feather River Specific
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.		
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.		
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.		
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	While in shallow water, hitch larvae and small juveniles require vegetation, such as tule beds, as refuge from predators (Moyle 2002).	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	The main food base of juvenile hitch includes phytoplankton, algae, crustaceans, gnats, and other insects (Wang 1986). Juveniles smaller than 2 inches (50 mm) in length in the near-shore environment feed on larvae and pupae of chironomid midges, and other insects and small planktonic crustaceans (Moyle 2002). Clear Lake limnetic hitch longer than 2 inches (50 mm) feed primarily on *Daphnia* and other zooplankton, taking surface insects when abundant (Moyle 2002).	
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	Juvenile hitch feed primarily during the day (Moyle 2002).	
predation of juveniles	Indicate which species prey on juveniles.	Clear Lake hitch are preyed upon by herons, bald eagles, white pelicans, and other birds, and by largemouth bass and other introduced fishes (especially centrarchids) (Moyle et al. 1995).	
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.		

Element	Element Descriptor	General	Feather River Specific
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.		
Juvenile emigration			
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.	N/A	
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	N/A	
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	N/A	
emigration timing range	Time of year juveniles commence emigration and duration of emigration.	N/A	
emigration timing peak	Time of year most juveniles are emigrating.	N/A	
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.	N/A	
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.		
Other potential factors			
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish.		
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.		
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Hitch are widespread in slow moving, clear stretches of rivers and low-gradient streams (Moyle 2002).	

Element	Element Descriptor	General	Feather River Specific
factors contributing to mortality	e.g. fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	Principal threats to hitch are loss of adequate spawning flows in spring months (because of dams and diversions) and loss of summer rearing and holding habitat, in addition to pollution and predation by nonnative fishes (Moyle 2002). Principal threats to Clear Lake hitch include loss of habitat and loss of nursery areas, which are the same factors that strongly contributed to the extinction of Clear Lake splittail (Moyle 2002). Hitch survival is threatened in Clear Lake by establishment of threadfin shad, which feeds on *Daphnia*, a principal food of hitch (Moyle 2002). In Clear Lake, dams and diversions block hitch passage to the spawning grounds. Due to the species' slow critical swimming velocities, hitch often cannot make it across the barriers. Those that do are left unprotected in shallow water (Moyle 2002). The "sport" of "hitching" involves clubbing the hitch and throwing them onto shore (Moyle 2002).	

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